

EPA Programs of Vinyl Chloride Monitoring in Ambient Air

by W. Fred Dimmick*

Before development of an emission standard for vinyl chloride, the Environmental Protection Agency (EPA) conducted three programs to measure vinyl chloride (VC) concentrations in air around plants which either manufacture VC or use it. A brief monitoring survey conducted by EPA Regional Offices found VC in ambient air around poly(vinyl chloride) (PVC) production plants. As a consequence of this survey, a second monitoring program was established to measure VC in the air around VC and PVC production plants. This program found some relatively high concentrations of VC in ambient air around the plants. This program found maximum 24-hr average concentrations ranging from 0.32 to 10.6 parts of VC per million parts of air. The program also found an apparent relationship between certain emission excursions and ambient VC concentrations. A third monitoring program was established to measure VC around PVC fabrication plants. This monitoring program found much less VC around PVC fabrication plants than around VC and PVC production plants. In conclusion, VC was found in ambient air around VC production plants and PVC fabrication plants. However, the data show that much less VC escapes into surrounding air from PVC fabricating plants than from VC and PVC production plants.

Before development of an emission standard for vinyl chloride, the U.S. Environmental Protection Agency (EPA) conducted three programs to measure vinyl chloride (VC) concentrations in air around plants which either manufacture VC or use VC (1). The first program was a quick survey designed to estimate the magnitude of the ambient VC problem. The second was a program to measure VC around a VC manufacturing plant and around two plants that polymerize VC monomer to form poly(vinyl chloride) (PVC). And the third program was designed to measure VC around five plants that form the PVC into consumer products.

In early 1974, former EPA Administrator Russell Train established a task force to determine what action EPA should take to protect the public from inadvertent exposure to VC, a compound which had been shown to cause cancer in man. A major objective of the task force was to collect information on the concentration of VC in air

around VC and PVC plants. Because of the apparent urgency of the problem, it was decided that EPA Regional Offices should conduct a brief monitoring program around one or more plants in their region. Accordingly, on very short notice and with little equipment and planning, the seven Regional Offices where these plants were located carried out a brief monitoring program (2a). Table 1 lists the plants monitored.

The sampling and analytical procedures used for this brief monitoring program had not been rigorously tested at the time, but because of the urgent need for data, all Regional Offices attempted to follow the procedures carefully. Some were more successful than others. Both the sample collection procedures and the analytical procedure have subsequently been shown to be satisfactory.

Sampling was done in two ways: "discrete" samples (glass syringes, glass tubes, vacuum containers, or Tedlar bags) and "integrated" 24-hr samples (a known flow rate of air passed through a charcoal adsorption column for 24 hr) (2b). The samples were taken to a laboratory and analyzed by gas chromatography. Any vinyl chloride found in

*Emission Standards and Engineering Division (MD-13), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 27711.

Table 1. PVC plants monitored for ambient VC in spring 1974.

EPA region	Company	Location
I	Borden, Inc.	Leominster, Mass.
II	Tenneco Inc.	Flemington, N.J.
III	Diamond Shamrock Corp.	Delaware City, Md.
	Stauffer Chemical Co.	Delaware City, Md.
IV	B. F. Goodrich Co.	Louisville, Ky.
V	Uniroyal, Inc.	Painesville, Ohio
	Robintech, Inc.	Painesville, Ohio
VI	Goodyear Tire Co.	Plaquemine, La.
IX	American Chemical Corp.	Long Beach, Calif.
	B. F. Goodrich, Co.	Long Beach, Calif.

Table 2. Summary of VC monitoring data: 1974.

Region	Sampling period	No. of samples	Maximum VC, (v/v)
I	May 9, 10, 13	157 discrete	6.0
		12 integrated	1.0
II	May 29-31	43 discrete	0.05
		23 integrated	0.031
III	May 20-22	5 discrete	0.7
IV	May 8-16	108 discrete	33
		35 integrated	0.53
V	May 9-14	137 discrete	2.26
		9 integrated	0.2
VI	April 7-9	31 discrete	7.8
IX	May 7-10	180 discrete	3.4

the samples could then be expressed as an "instantaneous" concentration (micrograms per cubic meter, $\mu\text{g}/\text{m}^3$, or parts per million by volume, ppm) for discrete samples or as 24-hr average concentration for a 24-hr integrated sample.

The results from this brief monitoring program were, perforce, less than satisfactory. Table 2 summarizes the data gathered around each plant (2a). Lack of equipment, unskilled personnel and unusual weather patterns combined to produce many blank samples or data of unknown accuracy. The most important conclusions from the experiment were that VC could be found in ambient air near PVC plants and that a much better monitoring program was needed. It must be remembered that the analytical accuracy is unknown, and that low values could mean either low emissions from the plant, adverse meteorology, or inappropriate sampling times.

From this brief program it was apparent that vinyl chloride could be found in ambient air around PVC plants and that a more rigorous monitoring program was warranted. Accordingly, a major effort went into setting up and carrying out a study of the VC around two PVC plants and one plant which produces the VC monomer. Simultaneously, a more modest study was begun to measure the VC around plants which fabricate PVC into consumer products, because the fabricating operations can liberate occluded VC from the PVC raw material.

The major monitoring program carried out by EPA was designed to validate a mathematical model which attempted to simulate emissions from any VC or PVC plant (3). Table 3 summarizes the sampling periods at the VC and PVC plants chosen for the program. A number of 24-hr integrated samplers were set up around each of these plants at various directions and distances after a study of the meteorology of the area. In general, two samples were collected per week at each sampling site and

returned to the laboratory for gas chromatographic analysis. The majority of the stations were in the predicted downwind direction, while a smaller number was distributed in upwind directions in order to establish background levels of VC in the incoming air. Partway through the program, when it became clear that the prevailing meteorological patterns were different from the predicted ones, it was decided to concentrate all samplers for one-month periods at two of the plants in sequence.

In addition, one continuous sampler was used during the sampling program at Aberdeen and two and three continuous samplers were used during the sampling programs at Norco and Louisville, respectively. The purpose of these samplers was to evaluate their reliability and to observe any rapid excursions of vinyl chloride, should they occur. Information from these samplers was limited because, on many days, they did not operate due to malfunctions.

The data collected at the sampling sites are summarized in Table 4 (3). Interpretation of the data would be useful in two respects. First, it would be useful to determine if there are any relationships between peak concentrations and specific emission sources or plant operations, and if so, to define these relationships. Second, it would be useful to evaluate the significance of the results in terms of public health effects. Any interpretations are limited by a couple of factors, however. First, a large portion of the samplers were located on plant property rather than in residential areas because the purpose of the sampling program was to validate a mathematical model. Second, during the sampling programs, VC and PVC plants in general were not operating at their normal capacities due to economic conditions. The VC plant used in the program was operating between 50 and 110% of its capacity, averaging about 70%. Also, in PVC plants particularly, there are a large number of emission

Table 3. Sampling periods at VC and PVC plants.

Location	Company	Number of 24-hr integrated samplers	Dates
Norco, La.	Shell Chemical Co. (VC production)	15 30	Nov. 19-Apr. 8, 1975 Apr. 8-May 5, 1975
Aberdeen, Miss.	Conoco Chemical (PVC production)	15	Nov. 6-Mar. 27, 1975
Louisville, Ky.	B. F. Goodrich (PVC production)	17 38	Nov. 6-May 15, 1975 May 15-June 12, 1975

Table 4. Results from vinyl chloride sampling program around VC and PVC plants.

	Norco (VC)	Aberdeen (PVC)	Louisville (PVC)
No. of samples	708	483	712
Arithmetic mean, ^a $\mu\text{g}/\text{m}^3$	3.4	11.6	11.4
Maximum value found (24-hr average) $\mu\text{g}/\text{m}^3$ ppm	27,046 10.6	23,430 9.2	810 0.32

^aValue for distances > 1000 m from plant.

sources and fluctuations in emissions. PVC production, unlike VC production, is largely a batch operation rather than a continuous operation. Since only abnormal plant occurrences were requested to be reported to EPA, normal fluctuations in emissions cannot be compared with ambient concentrations. Furthermore, the placement of samplers and the meteorological conditions at the time of an emission excursion are important in determining which samplers, if any, are affected. Obviously, enough samplers cannot be placed around a plant to pick up all emission excursions. Also, the degree of variability in meteorological conditions during the 24-hr period when an integrated sample is collected affects the amount of VC collected in that sample.

Although definitive conclusions cannot be made about the results from the sampling program, observations can be made by selecting out the relatively high readings, looking at the wind speed and direction, and thereby determining the probable source of emissions. The maximum 24-hr average value observed at the Louisville PVC plant occurred on a day when a relatively large number of the samplers both on and off plant property (9 out of 38) had relatively high readings (500 $\mu\text{g}/\text{m}^3$ or 0.198 ppm) compared with other-day samples taken at this plant (1). The only nonroutine operation recorded by the plant that day was a reactor relief discharge. This is not necessarily the cause of the higher values obtained by the 24-hr samplers due to

their long averaging time. However, there were three peak 1-hr average values on the continuous monitor that day (2.00 ppm, 2.00 ppm, and 2.44 ppm). Two of these occurred about the time of the relief discharge. The wind was blowing in the direction of the continuous monitor at that time. There were several other days during the sampling program on which there were relief discharges. On all of these days except one, the continuous monitors were not operating. On that day, one monitor was operating but the wind was not blowing from the plant to the monitor.

PVC is formed into thousands of user-products, but the majority of the material goes into a relatively few basic products. It was decided that the PVC fabrication plant study should focus on five of these large-use products and that the largest plants producing these products should be monitored, if at all possible (4a). Table 5 lists the pertinent information about these plants.

The PVC fabrication plant study consisted of collecting 24-hr integrated samples daily on each of the four sides of the plants, as close to the fence line as possible, for two week periods. A minimum of 56 samples were thus collected at each plant. The samples were returned to the laboratory and analyzed by gas chromatography. Table 6 summarizes the data from this study (4b). A rigorous quality

Table 5. Plants monitored during the PVC fabricator study.

Company (principal product)	Location	Dates of sampling
Ford Motor Co. (Upholstery products)	Mt. Clemens, Mich.	Feb. 12-26, 1975
Congoleum Industries (floor coverings)	Marcus Hook, Pa.	Mar. 12-26, 1975
Reynolds Metals Co. (packaging materials)	Grottoes, Va.	Mar. 15-29, 1975
Charlotte Pipe and Foundry (pipe and fittings)	Monroe, N.C.	Apr. 10-24, 1975
ITT Co. (cable coverings)	Pawtucket, R.I.	May 22-June 5, 1975

Table 6. Summary from the PVC fabricator study.

Plant	Location	No. of samples collected	Maximum VC found, ppb	No. of samples with no VC
Ford Motor Co.	Mt. Clemens, Mich.	64	7.0	55
Congoleum Ind.	Marcus Hook, Pa.	63	4.0	26
Reynolds Metals	Grottoes, Va.	61	2.0	18
Charlotte Pipe and Foundry	Monroe, N.C.	62	0	62
ITT Co.	Pawtucket, R.I.	63	0	63

Table 7. Vinyl chloride ambient concentrations estimated by diffusion modeling: 24-hr average maxima.^a

Model plants (size)	Ambient air concentrations (24-hr average maxima), ppm (unregulated prior to 1976)
Vinyl chloride plant-average (318 million kg production per year)	0.97
Vinyl chloride plant, large (590 MM kg/yr)	1.8
Poly(vinyl chloride) suspension and dispersion plant, average (54 MM kg/yr 14 MM kg/yr)	11
Poly(vinyl chloride) suspension and dispersion plant, large (112 MM kg/yr/45 MM kg/yr)	27
Poly(vinyl chloride) suspension plant, average (68 MM kg/yr)	10
Poly(vinyl chloride) suspension plant, large (159 MM kg/yr)	23

^aThe plants were evaluated by using meteorological data from Houston, Texas. Receptors were assumed to be located at 80 m in intervals from the center of the plant. Effective height of emissions was the stack height. Fugitive emissions were treated at 100 × 100 m area sources at 6 m above ground. Other sources are all treated as point sources, located at the center of the area source.

control program was instituted at the beginning of the study, so that the analytical data are considered reliable. In addition, some duplicate samples were collected and analyzed by independent laboratories, thus adding to the confidence in the data. The minimum detectable concentration of VC by the method used was 0.5 ppb. The data show that much less VC escapes into surrounding air from PVC fabricating plants than from VC and PVC production plants.

During the development of the emission standard for vinyl chloride promulgated on October 21, 1976, dispersion modeling was applied to estimate the impact of alternative control levels on ambient concentrations of vinyl chloride resulting from unregulated emissions. The ambient concentrations

were calculated in terms of 5-min averages, 24-hr averages, and annual averages (5). Table 7 shows 24-hr average maximum concentrations. These concentrations can be compared to the ambient monitoring information found in Table 4. For example, the 24-hr maximum average value found at the Norco plant was 10.6 ppm, and an estimated concentration would be about 1 ppm. In another example, the 24-hr maximum average value found at the Aberdeen PVC plant was 9.2 ppm, and an estimated concentration would be about 20 ppm.

In conclusion, VC was found in ambient air around VC production plants, PVC production plants and PVC fabrication plants. However, the data show that much less VC escapes into surrounding air from PVC fabricating plants than from VC and PVC production plants.

REFERENCES

1. EPA. EPA Programs of Monitoring Vinyl Chloride in Ambient Air. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, 1976, pp. 1-14.
2. EPA. Preliminary Assessment of the Environmental Problems Associated with Vinyl Chloride and Polyvinyl Chloride (Appendixes). U.S. Environmental Protection Agency, Office of Toxic Substances, Washington, D.C., 1974, (a) pp. 26-30; (b) pp. 17-25.
3. EPA. Scientific and Technical Assessment Report on Vinyl Chloride and Polyvinyl Chloride (EPA-600/6-75-004). U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, North Carolina, 1975, pp. 29-32.
4. EPA. Monitoring Vinyl Chloride Around Polyvinyl Chloride Fabrication Plants. U.S. Environmental Protection Agency, National Environmental Research Center, Research Triangle Park, North Carolina, 1975, (a) pp. 1-3; (b) pp. 4-1 to 4-6 and pp. E-1 to E-7.
5. EPA. Standard Support and Environmental Impact Statement—Emission Standard for Vinyl Chloride (EPA-450/2-75-009). U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, 1975, p. 6-14.